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Influence of calcium carbonate and charcoal application on aggregation processes and organic matter retention at the silt-size scale

Asmeret Asefaw Berhe (1), Michael Kaiser (2), Teamrat Ghezzehei (3), David Myrold (4), and Markus Kleber (5)

(1) School of Natural Sciences, University of California, Merced, United States (aaberhe@ucmerced.edu), (2) Department of Environmental Chemistry, University of Kassel, Witzenhausen, Germany, (3) School of Natural Sciences, University of California, Merced, USA, (4) Department for Crop & Soil Science, Oregon State University, Corvallis, USA , (5) Department for Crop & Soil Science, Oregon State University, Corvallis, USA

The effectiveness of charcoal and calcium carbonate applications to improve soil conditions has been well documented. However, their influence on the formation of silt-sized aggregates and the amount and protection of associated organic matter (OM) against microbial decomposition is still largely unknown. For sustainable management of agricultural soils, silt-sized aggregates (2-53 μm) are of particularly large importance because they store up to 60% of soil organic carbon with mean residence times between 70 and 400 years. The objectives are i) to analyze the ability of $CaCO_3$ and/or charcoal application to increase the amount of silt-sized aggregates and associated OM, ii) vary soil mineral conditions to establish relevant boundary conditions for amendment-induced aggregation processes, iii) to determine how amendment-induced changes in formation of silt-sized aggregates relate to microbial decomposition of OM. We set up artificial high reactive (HR, clay: 40%, sand: 57%, OM: 3%) and low reactive soils (LR, clay: 10%, sand: 89%, OM: 1%) and mixed them with charcoal (CC, 1%) and/or calcium carbonate (Ca, 0.2%). The samples were adjusted to a water potential of 0.3 bar and sub samples were incubated with microbial inoculum (MO). After a 16-weeks aggregation experiment, size fractions were separated by wet-sieving and sedimentation. Since we did not use mineral compounds in the artificial mixtures within the size range of 2 to 53 μm, we consider material recovered in this fraction as silt-sized aggregates, which was confirmed by SEM analyses. For the LR mixtures, we detected increasing N concentrations within the 2-53 μm fractions of the charcoal amended samples (CC, CC+Ca, and CC+Ca+MO) as compared to the Control sample with the strongest effect for the CC+Ca+MO sample. This indicates an association of N-containing microbial derived OM with silt-sized aggregates. For the charcoal amended LR and HR mixtures, the C concentrations of the 2-53 μm fractions are larger than those of the respective fractions of the Control samples but the effect is several times stronger for the LR mixtures. The C concentrations of the 2-53 μm fractions relative to the total C amount of the LR and HR mixtures are between 30 and 50%. The charcoal amended samples show generally larger relative C amounts associated with the 2-53 μm fractions than the Control samples. Benefits for aggregate formation and OM storage were larger for sand (LR) than for clay soil (HR). The gained data are similar to respective data for natural soils. Consequently, the suggested microcosm experiments are suitable to analyze mechanisms within soil aggregation processes.